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Data are presented from one subject (J) that show a gradual development of the complexity of words in terms of syllable structure and degree of phonetic similarity of co-occurring consonants. During the age range of 1;9 to 2;6, J's data show a highly systematic progression of stages, each characterized by fewer restrictions on the number, order, and type of syllables and on the co-occurrence of consonants than earlier stages. The possibility is noted that the systematicity of the corpus may be related to the fact that J was a non-imitator for the first four months of testing. Several types of data support the interpretation that the limits on complexity seen at each stage of development are limits on the child's production (not perception or storage) at that time. It is suggested that, for this child, the "word" is the unit of production performance in terms of which the phonological complexity is constrained. Within such a context, the limitations on complexity seen in J's phonological data may reflect a general psychological process, similar to that noted in other aspects of language acquisition. (Author/NCR)

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PERMITTED COMPLEXITY IN PHONOLOGICAL DEVELOPMENT: ONE CHILD'S ACQUISITION OF SPANISH CONSONANTS

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ABSTRACT

Data are presented from one subject (J) which show a gradual development of the complexity of words in terms of syllable structure and degree of phonetic similarity of co-occurring consonants. During the age range of 1;9 to 2;6, J's data show a highly systematic progression of stages, each characterized by fewer restrictions on the number, order and type of syllables and on the co-occurrence of consonants than earlier stages. The functioning of the three major classes of consonants is described in terms of a strength hierarchy. The possibility is noted that the systematicity of the corpus may be related to the fact that J was a non-imitator for the first four months of testing. Several types of data support the interpretation that the limits on complexity seen at each stage of development are limits on the child's production (not perception or storage) at that time. It is suggested that, for this child, the 'word' is the unit of production performance in terms of which the phonological complexity is constrained. Within such a context, the limitations on complexity seen in J's phonological data may reflect a general psychological process, similar to that noted in other aspects of language acquisition.

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> The interpretation also fits with the notion of a limit on the permitted complexity at [any] one stage.
>
> Bellugi 1968, 40.

0. Introduction

One child's acquisition of the consonants of Mexican Spanish will be presented here to show the gradual development in the phonological complexity of words which is characteristic of this child's development through the period of 1;9 years to 2;6 years. It will be argued that restrictions on syllable structure and on the co-occurrence of consonants limit in systematic ways the complexity of all words during that period, and that the development in complexity of his production can best be accounted for in terms of successive modifications of these restrictions.

The data reported here are from one subject (J) out of six who participated in a longitudinal study designed to investigate the acquisition of consonants in monolingual Mexican-Spanish speaking children. This study is part of the on-going cross-language research activities being conducted by the Stanford Child Phonology Project. Most of the research that the Project has done in the past has been on the acquisition of English phonology (e.g., Garnica 1973, Ferguson, 1975, Ferguson/Farwell 1975, and Edwards 1975). Within the past few years, several Spanish studies (of which this is one) have been completed (e.g., Stoel 1974, Hernández et al. 1975, and Macken 1975). Within the next year, the set of languages in which research is being conducted will be expanded to include Cantonese Chinese in addition to American English and Mexican Spanish.

1.0 Data collection and analysis

The data collection and analysis procedures will be described in this section as they apply to the longitudinal study as a whole; all subsequent sections will concern only the one subject J.

Six criteria were used in selecting the subjects (Ss): sex, age, exposure to English, stage of phonological development, sociability and neighborhood relations. Basically, all children who participated were young (1;5 to 1;6 at the beginning of testing), had a limited phonological system (i.e., no more than one fricative and/or liquid) and were essentially monolingual Mexican-Spanish speakers (Michoacán dialect area).

The subjects were seen once a week for an eleven-month period. Each week, all six children came to a community center near their homes, the Fair Oaks Community Center, Redwood City, California, where the Project had use of two classrooms. The children were tested individually, and while the testing was being conducted in one classroom, the other room served as a playroom. During testing, each child was tape-recorded for

fifteen to thirty minutes, while interacting with the experimenter (E), a native speaker of Mexican-Spanish. Recording was done on a Uher 4000 tape recorder, with a Sony Electret microphone(attached to a soft cloth vest which the child wore).

Later, transcriptions were made of all tapes, by two transcribers working independently and using Revox A77 tape recorders, with Super St-Pro B-V headphones. Two procedures were used to combine the individual transcriptions of each utterance into a final one. For the data from the first twelve testing sessions, the two researchers re-listened to the tapes, compared the individual transcriptions and reached agreement on a final transcription. As a result of the high correlation between individual transcriptions, and the comparatively small gains achieved by the second listening, this procedure was changed. For data from the subsequent sessions, one transcriber worked with the two transcripts and compiled a final transcription for each utterance. Where differences existed in the individual transcriptions between two symbols (e.g., [b] versus [p]) or between crucial diacritic markings (e.g., lateralization versus nasalization of a vowel), both transcriptions were noted; these alternative transcriptions are indicated in the text with a slash. For example, in peine 'comb' ['b/pe$^{\text{I}}$p̰ e] (1;11) the slash indicates that the two transcribers disagreed on the voicing of the initial consonant.

The transcription system used is that of the International Phonetic Association, with a child language diacritic system and supplemental symbology developed by the Stanford Child Phonetics Workshop (Bush et al., 1973). The appendix lists and explains unusual symbols and diacritics used in the examples for this paper.

During most of the sessions, an observer was present who took notes on the child's pronunciations and word referents. Four types of stimuli were used to elicit speech: (1) small toy objects (e.g., spoon, cup, plate, bear, car, comb, bed, doll, etc.); (2) picture books; (3) 4" x 6" index cards, each with a simple picture of a common object; and (4) nonsense VCV[1] stimuli read by E from 3" x 5" index cards. In the VCV's, all Spanish consonants were rotated through three vowel environments a__a, i__e and u__o. All children responded with spontaneous speech to the toy objects (stimulus category 1, above), and all the children, at some point, began to verbalize in response to the picture books (2). Later in the course of the study, all of the Ss would verbally respond to, spontaneously

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[1] Capital letters will be used throughout as follows: C = consonant, V = vowel, F = fricative, S = stop, L = liquid, G = glide. A circle appearing below the symbol indicates 'voiceless' (F̰ = voiceless fricative), while a small 'v' means 'voiced' (F̬ = voiced fricative). Consonant co-occurrence will be noted in terms of combinations of such symbols.

name, or imitate the names of the objects pictured on cards (3), although individual children differed significantly in when and how often they would respond to this stimulus type. Later still in the course of the study, a few children would imitate the nonsense stimuli when read out by E (4). Thus, the stimuli used elicited both spontaneous and imitated speech.

When the children were not being tested, they remained in the playroom, where they played with each other, with either of two research assistants and/or with a large array of games, books and toys. Informal notes were taken in the playroom by one of the research personnel. For each child, these notes included: words which the child used, the referents, a sketchy description of the context, and a broad transcription of the child's pronunciation; a brief description of how the child obtained objects, food, attention (i.e., if and how the child used language), and how she/he interacted with the other children and with the adults; comments on favorite toys, developmental milestones, and, in general, whatever seemed most salient about each individual child.

One of the purposes of the playroom notes was to determine the child's vocabulary. In addition, word lists were collected weekly or bi-weekly from the parents. When it was discovered in the playroom that a child liked a particular book, set of puzzle pieces, or toy, or that she/he used particular words in the playroom or at home (e.g., nick-names of siblings or friends), this information would be used to elicit vocabulary items; if these techniques failed to spontaneously elicit the items, the child was asked to imitate them. These efforts were made in order to insure that elicitation techniques used in the testing room resulted in as nearly complete a recording of the child's words as possible.

2.0 The subject

J was added to the study a month late, in order to replace one of the original six subjects. He was 1;8 at the beginning of testing, which was only three weeks older than the oldest original S. Two sessions elapsed before J felt comfortable enough to talk, which was typical of the behavior of all the children. (Only one S (Si) talked on the first session.) At the third session, which marks the beginning of J's data, he was 1;9. Data is complete for him for six months (1;9 to 2;3) and for another month (2;4½ to 2;6), which followed a one and one-half month hiatus in his testing. During the first six-month period, he was tested twenty-two times and during the final month, he was seen six times.

In the testing situation, J was among the first of the children to respond to all four stimulus types described above and was one of only two Ss who, later in the study, would fairly consistently imitate the VCV nonsense stimuli. In the playroom, J was both quite active physically and quite verbal, one of the two most verbal children in the S population.

2.1 J's background

J was born in Redwood City, California, and his family has lived at various times in that city and in Mexico since. He has two sisters (aged seven and nine, at the beginning of the study) and one brother (aged eight), all of whom had begun to learn English in school, although they attended very irregularly. Both parents are Mexican-born, native Spanish-speakers (as are J's older siblings): the mother's dialect area (and that for all other parents of the Ss) is Michoacán, Mexico, and the dialect area for the father is Texas, U.S.A. The father, who spoke some English at the time that the Project was started, began taking daily English classes in April (when J was 2;1) and continued these for about three weeks. His mother speaks only Spanish. Spanish is the language used in the home, although some English lexical items are used. (The family also has a television set.) Although J is exposed to some English, did learn several English words during the time we saw him, and will be encouraged by his family to learn English, his language throughout the period of the study was Spanish. Nine words of English origin appeared in J's speech (see Table 1). Probably all of these were used by his parents or siblings in their Spanish, and there is no evidence that he handled the phonological structure of these words in any way differently than other Spanish words. One of the words, cookie, is a fully assimilated Spanish word in the local Mexican-American community.

Table 1. Words of English origin in J's speech*

	English	Date 1st appears in test session	J's age	Typical phonetic form
(1)	cookie	1/31	1;10	'ku ki
(2)	school	2/ 7	1;11	ku
(3)	spoon	2/21	1;11	pom
(4)	car	3/21	2;0	ka
(5)	milk	3/28	2;0	'mo ko
(6)	shoe	4/ 4	2;1	su
(7)	apple	4/25	2;1	^{h}ap_p^{h}u
(8)	(monkey)	5/23	2;3	mɔn_nɪ^{h}
(9)	phone	8/15	2;5	ɸfɔn

*Notes

(1) Proper names are not included.

(2) All the words were used frequently by J, each for different lengths of time, except for the following: car was used only occasionally and for a brief time period; (monkey) and phone were produced only once.

(3) Milk and apple contain non-Spanish clusters, but the way in which J handled them is not inconsistent with his general phonological processes.

(4) The source for monkey may have been Spanish mono 'monkey'.

2.2 J as imitator

J was chosen as the subject for the present paper as a result of the systematicity of his phonological development, in particular, the regularized growth in the word complexity of his productions. Of additional and related interest is the fact of his non-imitation. Throughout the first four months of testing, J very rarely imitated the speech of an adult in his ordinary behavior, and in the testing situation he refused, with much greater consistency than any other S, to imitate when specifically requested to do so. J's non-imitation can be viewed as a type of 'avoidance' behavior. The term 'avoidance' will be used here to cover two distinct but related types of behavior. The first type is that which corresponds to the most usual use of the term: J typically refused to imitate when specifically requested to do so. The second is a pattern of 'conversational behavior' which, although not a direct refusal to imitate, resulted in the same effect, i.e., the absence of imitation. J's specific, direct non-imitation and his general 'conversational behavior' both show that he did not use imitation to any significant degree as a means of interacting with and learning about his environment (at least during this stage of his development). The absence of imitation or mimicry is very striking in J's behavior--particularly when J is compared to other Ss--, and the use of the cover term 'avoidance' is an attempt to capture all aspects of this.

In direct non-imitation, when J was asked to imitate a word, he would usually ignore the request and would respond with ¿huh?, several types of distractors (e.g., ésta 'this', while pointing to a new object; or a content word which served to shift the topic), and occasionally with silence. A response of silence is only included in the tabulations for avoidance if E explicitly requested imitation and J appeared to be attending. Two exchanges from 1/31 (when he was 1;10) show typical responses to a direct request for imitation:

	E		J	
I.	¿Te gusta la sopa?	'Do you like soup?'	[nods yes]	
	Di sopa.$_{3x}$	'Say "soup"'	¿huh?$_{3x}$	
II.	Di cuchara.$_{3x}$	'Say "spoon"'	¿huh?$_{3x}$	
	¿Qué es?	'What is it?'	Este.	[pronounced with falling intonation, and accompanied with pointing to a different object]

In both I and II, J appeared to be attending to the relevant picture or object, and yet each of the three times that the 'say this' request was given, he responded with ¿huh?. The extremely frequent use of ¿huh?, ¡mira!, ésta/éste and sí was typical only of J, among the six subjects.

In other conversational behavior (i.e., when not explicitly asked to imitate), J produced similar responses. The few words which he did imitate were those for which he gave clear evidence of understanding the meaning, while new words or words for objects which were of no interest to him often elicited ¿huh?. When, at age 1;11, he learned to pronounce sí 'yes', ¿huh? dropped dramatically in frequency, and sí became his favored response. Of equal frequency to ¿huh? (and later to sí) were two deictic words: ¡mira! 'look!' ([hja]) and ésta/éste 'this [is]' ([ˈᵇᵉˈt̪ːa] ~ [tʰˈːa]).[2] Although éste and ésta are different forms in the adult language (masculine and feminine respectively), J's productions typically ended with an /a/- like vowel, and he did not make a consistent distinction in meaning for the two forms; they are therefore treated as one word in the data analysis. Both of these words were usually accompanied by pointing (to a new or previously unmentioned object) and functioned as requests for an action (usually for E to name an object).

Of equal frequency and more characteristic of the subjects as a whole, were the responses in which J offered an associated word--most often a 'favorite word'. For example, the E's discussion of el perro 'the dog' would be followed by J's comment guau-guau 'bow-wow' (which was his early and only word for all animals). J had a small number of favorite words which were usually over-extensions (or in some cases homonyms) which he used very frequently: e.g., manzana 'apple' was used for all fruit, balls, round objects (e.g., eggs, onions, eyes) and occasionally for an animal (possibly referring to the eyes?); agua 'water' was used for water, juice, cups, boats, soap bubbles and also apparently for colors (blue sky, green cover of a book, yellow, and gold pigs) and balls and balloons (possibly from bola 'ball' (of thread, etc.) a homophone with agua?). Two other types of association replies were (a) J's responses of a previously mentioned object or a new object or picture on the same page or card which was related to E's topic in some way, and (b) his responses of a strongly associated word (e.g., E's zapato 'shoe' would be followed by J's chuchi a nickname, which probably meant 'Chuchi has a shoe'; E's casa 'house' would almost always be followed by J's mama 'mother', which apparently meant something like 'Mama is at home').

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[2] Here, and throughout the paper, the phonetic forms found in brackets are transcriptions of words as they were actually produced on a particular occasion; these forms were selected, however, as examples because they were representative productions for the particular words.

J's avoidance of direct imitation and the absence of imitation in his conversational behavior suggest that imitation, even as a means of social interaction, served little function for him in general, and he particularly avoided imitating either words which were unfamiliar to him, or words which he clearly understood but for some other reason did not want to say.[3] It appears that, at least some of the time, he avoided imitating some words on the basis of how difficult they were to pronounce. It is the latter situation which provides evidence for phonetically motivated avoidance strategies, similar to those reported in Ferguson/ Farwell 1975.

J's early sessions were characterized by a very small number of words, with highly similar lexical sets for the spontaneous and imitated corpora, and very little phonetic difference between the spontaneous and the imitated productions of any given word. Of the thirty-one different words he used during the first month of testing (i.e., the first four sessions), seven were imitated but never spontaneously produced. Of these seven words, only three (mono, mano and tu) did not appear spontaneously within the following two sessions, which would be expected on the basis of order of appearance relations for other words. These three words, however, are similar in phonological structure to other words which he did produce in the early sessions. Since (as noted earlier) J was quite verbal, these thirty-one words appear quite frequently in the four sessions (a total of 465 tokens). Of the forty-eight words which he avoided in some way during the four sessions, eleven were also among the thirty-one which he would spontaneously use or imitate on other occasions, indicating that he would not necessarily imitate even when he knew and used a word spontaneously. On the other hand, only three avoided words were similar enough to his production abilities (as evidenced in other words) to be exceptions to a general phonetically motivated avoidance strategy: casa, gato, and peine.

It is not clear whether or to what extent the systematicity of his data is related significantly to his being a non-imitator. To resolve this question, longitudinal data from a set of children who imitated and a set who did not imitate would have to be compared. Such a comparison for the six subjects of this study will be attempted when the data from all six have been analyzed. For the moment, a brief comparison of J with Si, an 'imitator', will be made, since it is useful for its suggestion that what distinguishes J's 'more systematic' phonological corpus from Si's 'less systematic' one--is a general personality (and/or cognitive) style such as non-imitator versus imitator rather than an exclusively phonological strategy.[4]

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[3] See Keenan 1974, Bloom et al. 1975, and Nicolich 1975 among the many recent papers on imitation for different views on its role in language acquisition.

[4] Two recent papers report on similar aspects of systematicity in phonological development: Waterson 1975 correlates the systematicity of her S's phonological and syntactical development with his 'high degree of intelligence'; and Vihman 1976 correlates her S's use of phonological avoidance strategies with the child's 'cautious personality.'

If all six Ss are judged on a scale of degree of imitation, J falls at the extreme non-imitation end, and Si (a female child, three weeks younger than J) is at the other end. None of the other four children would fall as clearly into either the category 'imitator' or 'non-imitator'. In the one task which required imitation (of the nonsense stimuli), all six subjects initially refused to imitate, and most continued to do so. J and Si, however, were the first to accept this task and the only two Ss who would fairly consistently agree to imitate the nonsense stimuli. Even so, J on occasion would refuse to do the task while Si never did, and Si would occasionally request to do it a second or third time while J never made such a request. J's reactions to the nonsense stimuli were most typical of the Ss as a whole.

In personality, Si was more gregarious and responsive than J, imitating everything during testing sessions and extremely verbal in interacting with E. She was frequently quiet in the playroom, playing by herself for long periods of time without speaking and only occasionally initiating verbal interaction with an adult or another child, but when a conversation was initiated by someone else, she always responded and comparatively long conversations followed. In the playroom, J, on the other hand, used more goal-directed language: he would use language to request food, to get an adult to play with him or look at something he was playing with, and less frequently, to initiate a conversation with another child. As a result, he frequently talked more than Si did in the playroom.[5]

In several different types of situations, J and Si responded in markedly different ways. In learning or problem-solving situations, Si was more spontaneous and impulsive, frequently exhibiting a random, trial and error approach. J, in contrast, was more deliberate and self-conscious--in appearance, more systematic. In response to new situations and strangers (e.g., a video-taped session), J--self-conscious and withdrawn--talked very little; Si, on the other hand, behaved no differently than on any other occasion. When tested on discrimination tasks (which used as stimuli, pairs of consonants which were produced homophonously by the child being tested), J succeeded on all three pairs tested, while Si had difficulty and needed three training sessions. J's easy success on these discrimination tasks, and the careful way in which he approached the learning of them are consistent with his general personality style and with his general awareness of language and the sounds of language--an awareness not so noticeable in Si.

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[5] Neither Si nor J were as interested in using language to interact socially as was R, the other very verbal subject. R would frequently declare her affection for children and toys in the room, greet incoming people, attempt to engage other children in activities (such as eating, and sharing toys), and in general accompanied her activities with some commentary--which neither J nor Si did to the same extent.

Although the data analysis for Si has only begun, she differed from J in many respects: she used a much larger number of words (including many over-extensions); had a different set of conversational strategies, none of which could be easily interpreted as avoidance mechanisms; imitated freely and for the most part, non-selectively (i.e., new words both well within and far beyond her production abilities at any given stage); and demonstrated much greater variability in her productions of words (e.g., spontaneous versus imitated forms). The variation in Si's corpus contrasts with the close correspondence between the phonotactic structure of the adult words and J's output, and between the phonological structure of his spontaneous and imitated productions.

Although J was a non-imitator during the first four months of testing, a dramatic change in his rate of imitation occurred at 2;0-2;1. Table 2a shows the proportion of imitated versus spontaneous productions for four sessions from 3/14 to 4/25. Against a low 14% for imitated words (versus 86% spontaneous) in the session on 3/14 (which is typical of the ratios of spontaneous to imitated for the preceding sessions), 42% of J's productions were imitations on 3/21 and a high of 79% were imitations on 4/18. Whereas before the age of 2;0, J would avoid many words and refuse to imitate, beginning at about 2;1 J would imitate E rather than spontaneously produce his own words.[6] Such high percentage figures for imitated as opposed to spontaneous forms continue for several sessions, and then drop but never again are as low as during the first four months. This shift in willingness to imitate is reflected in a dramatic decline in avoidance, from 89% of the adult words to which he attended in March to 12% of the adult words to which he attended in late April (see Table 2b). This dramatic shift in the distribution of spontaneous versus imitated forms in J's corpus suggests that his early non-imitation may have been a developmental stage (albeit particular to him and not, at least, to Si), and that the reasons for its existence no longer operate at age 2;1. Given that J showed more awareness of the sounds and structure of words than some of the other Ss and that his non-imitation was consistent with his deliberate approach to problem solving and with his self-conscious behavior in new situations, it may be that the shift from non-imitation to imitation signals an increase in his confidence and in his ability to handle language. The shift did in fact occur at a time in which he was able to handle most of the sounds of his language, had begun using many poly-syllabic words and also used many two- or more-word utterances. However, it did not correlate exactly with any specific or dramatic change in his phonological system: even after this point, the same processes operated to limit the complexity of difficult words as did before.

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[6] This shift in the rate of imitation is similar to the findings of Nicolich 1975; the opposite finding is reported in Bloom et al. 1975, where although there were inter-subject differences in the extent of imitation, each child was consistent across time in the tendency to imitate or not imitate. These differences may be related to the differences in age and developmental stage of the various subjects.

Table 2 J's change in imitation behavior at 2;0-2;1

a. J's productions

Session date	J's age	Total # of tokens produced by J	Individual words				
			Total words produced	Spontaneously produced words		Imitated words not spontaneously produced at any time	
3/14	2;0	308	36	31	86%	5	14%
3/21	2;0	218	31	18	58%	13	42%
4/18	2;1	169	61	13	21%	48	79%
4/25	2;1	176	61	23	38%	38	62%

b. J's responses

Session date	J's age	Adult words to which J attended	J's response			
			Imitation		Avoidance	
3/14	2;0	44	5	11%	39	89%
3/21	2;0	43	13	30%	30	70%
4/18	2;1	65	48	74%	17	26%
4/25	2;1	43	38	88%	5	12%

3.0 J's phonology at the beginning of testing

Since Project research has focussed primarily on consonants, in this section and in subsequent ones, only these sounds in J's phonology will be discussed. J's phonetic segments and phonetic sequences will occur within brackets, [...], the typical notation for such segments in descriptions of adult speech. His phonemes and phonemic sequences will be enclosed however by vertical straight lines, |...| , with the more usual slant lines / ... / reserved for phonemes or phonemic sequences of adult Spanish only. (This notation system is taken from Smith 1973.) Square brackets are used when no claim is made about phonological status; |...| and / ... / are used for surface segments presumed to be contrastive units for J and adults respectively.

Although there is some disagreement among linguists as to the exact classification of each of the Spanish consonantal phonemes, the basic sound classes generally recognized are stops, fricatives and sonorants. The feature of voicing is distinctive in the stops as /ptk/ versus /bdg/ and in the fricatives as /fsx/ versus [βðɤ]. However, the voiced fricatives are allophones of the voiced stops /bdg/: [bdg] occur in utterance initial position, and after certain sonorants; [βðɤ] occur in all other positions. Depending on the reference being cited, /tʃ/ is classified with the voiceless stops (Alarcos 1950), with the voiceless fricatives (Stockwell and Bowen 1965) or as the single member of a voiceless affricate class (Dalbour 1969). In the present paper, /tʃ/ will be referred to as a member of the voiceless fricative class. The greatest disagreement concerns the classification of /w/ and /j/: (1) as semivowels (Stockwell and Bowen 1965); (2) as fricatives (Dalbour 1969); or (3) in separate classes, the /j/ with /bdg/ as voiced or lax sounds, and [w] as a phonetic non-syllabic variant of /u/ or /gu/ (Alarcos 1950). In certain positions (V__V and $__) and particularly in andante speech style, /w/ and /j/ are strengthened to obstruents: [ɤʷ] for /w/ and [dʒ] for /j/ (Hooper 1972, 528; Harris 1969, 23-24). In parts of Mexico, the resulting confusion between /w/ and [ɤ] is particularly common (Stockwell and Bowen 1965, 65). The two sounds /w/ and /j/ will be referred to as glide consonants in the present paper. The class of sonorants is divided into the nasals /mnɲ/ and the liquids /lɾr̆/. The symbol /ɾ/ represents the apico-alveolar single flap r, and /r̆/ stands for the apical trill r phoneme. All eighteen consonant phonemes may occur in intervocalic position, and all but two (/ɾ/ and /ɲ/) may appear in initial position; in final position, however, only /ńsðlɾ/ may occur.[7]

In contrast to the adult phonemic system, J's consonantal phonology at 1;9 was characterized by a limited segmental system (section 3.1 below), several processes which simplified syllable/word structure (section 3.2), and severe restrictions on the co-occurrence of consonants (section 3.3); two minor processes also affected J's productions (section 3.4). The close

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[7] Final /ɾ/ represents a neutralization of the two r phonemes, and final /r/ represents a neutralization of all nasal phonemes (cf. Harris 1969 and Hernández et al. 1975).

similarity between the syllable and consonant structure of the adult words which J attempted and the structure of his productions suggests that J selected words for production partially on the basis of how easy they would be for him to handle.

In the following discussion of J's initial phonological system, the highly similar data from the 12/10 and 12/18 testing sessions are combined. In these first two sessions, J used twenty-three individual words a total of 207 times. However, J's two deictic words mira 'look' and ésta/éste 'this' account for 119 of the 207 productions. Although these deictic words will be referred to in the following sections when they exemplify aspects of J's general phonological system, they seem in many respects to constitute a category in and of themselves, somewhat apart from the core of that system. Both words were atypical of the types of adult words which J attempted in the first two sessions (see section 3.3), and his productions for these words were also unusual, in that both had a wider range of variation than other words, and each had a unique process associated with it.

An extremely clipped and frequently high pitched production was typical for only mira among J's words. Its variation included forms like the following (the first eighteen productions for mira on the 12/10 sessions): [m̥ʰi jə̃]; [hjə̃]$_{4x}$; [bi jə̃]; [ɓʲi ə]$_{2x}$; [hi jə̃]$_{4x}$; [ɻi jə̃]; [jə̃h]; [hĩ jə̃]$_{2x}$ and [i jə]$_{2x}$°. The unique process for mira is one in which both syllables are collapsed into one portmanteau syllable--[hjə], the most common rendition for mira throughout the period of testing. Also unusual is the systematic occurrence of [h] for /m/ in the form [hjə] (and in [hi jə] also); this substitution runs counter to the general nonphonological status of [h] elsewhere in J's phonology (section 3.1).

Esta/éste was produced for the first time on the 12/18 session as: (a) [hˢᵗ͡ɹə]; [hˢᵗ͡ɹə]; [hçt͡ɬah]$_{2x}$; [ᶠt͡ɬᵊa]$_{2x}$; [hˢᵗ͡ɬa]; and as (b) [t͡ɬʲjə] and [t͡ɬᵊə]$_{2x}$. The forms in (a) exemplify the unique process--'pre-closure frication'--associated with this word. This preclosure frication--apparently a word-specific strategy for the production of the st-cluster--was typical of his production of this word throughout the period of testing (1;9-2;6). This word was unusual in that no other /s/ + obstruent cluster was produced until 5/16 (age 2;2), when a production of vestido 'dress' appeared as [ɬsᵗ ʲə]. At the end of testing, only three st-clusters had been produced, and all three were atypical renditions of high frequency words which were otherwise produced without the cluster: 5/23 (2;2) pastel 'pie/cake' → [pɛ̞ˢᵗ͡ɬᵊe], and 8/15 (2;5½) pistola 'gun' → [pʰçʰɬ͡ɬol ɬa], [pɪᶠt͡ɬol ɬa]. The only other possibly similar case occurred during the brief period between 3/7 (2;0) and 3/14 (2;0½) (and possibly again on 4/25 (2;1½)) when spoon was produced as [havp͡pom]; in this word, J seems to have adopted a syllable strategy for the /s/+ obstruent cluster. Although preclosure frication occasionally occurred during the production of singleton stop consonants (as a result of J's immature articulatory control, e.g., aquí 'here' as [ᵉd̪ᵊᵉɾ̥] on 12/18), it did not occur systematically in any word other than ésta/éste.

3.1 Segmental system

From the beginning, J's consonantal inventory included the voiceless stops |ptk|, the nasals |mn| and the glides |wj| and [h]; it lacked the palatal nasal /ɲ/, the voiced stops /bdg/ and their intervocalic voiced fricative allophones [βðɣ], the voiceless fricatives /fsx tʃ/ and the liquids /lɾř/. Except for an occasional voicing of |t|, the voiceless stops were voiceless, even in utterance initial position. Generally absent was the 'initial voicing process,' widely reported for other languages in the child phonology literature (Ingram 1974).

J's glides were phonetic realizations of other consonants. The glide [w] was derived from /gu/, both [gu] and [ɣu], (through obstruent lenition) and from /m/ (through denasalization); later in the course of development, /bg/ and [β] were also realized as |w|. The appearance of [w] for /m/ demonstrates the difficulty that J had in temporally synchronizing the velic and oral movements required for the production of well-formed nasals; this difficulty with 'nasal synchrony' was typical of J's productions of nasals throughout the period of 1;9 to 1;11½. The glide |j| occurred in the first two sessions only as the phonetic form for /ɾ/ and in only one word, mira 'look'; later, all liquids, [ð] and /j/ were realized as |j|. [h] appeared either word initially before a vowel or word finally after a vowel; this phonetic devoicing of vowels in either initial or final position was also evidence of the difficulty that J had in synchronizing complex articulatory movements. At this stage [h] had no phonological status; later, it was a low frequency allophone of both |s| and |x| .

In addition to the above, well established consonants, there was some evidence that J's inventory was being expanded to include voiceless fricatives. In the second session, the first 'fricative' /tʃ/ was produced, and a second fricative, /x/, was realized as [w]. The production of these sounds marked the beginning of J's acquisition of the voiceless fricatives, a process which was still not complete by the end of testing when J was 2;6.

3.2 Syllable structure

In general, J's favored syllable/word structure was CV. This can be seen both in the production processes which adjusted adult CVCV and VCV words to the CV form, and in the evidence for J's selection of adult words which were of a structure close to the CV.

Three major processes combined to achieve the optimal CV syllable: (1) syllable deletion (guau guau 'bow-wow' → [wawʷ]; aquí 'here' → [ti]; taza 'cup' → ['t̪ʰja]; boca 'mouth' → [bʰă]; carro 'car' → ['kx̪ːwã]; pata 'paw' → [pʰẽ]; ésta/éste 'this' → ['t̪ʰe] [tʰa]; and mano 'hand' → [mʰmã]); (2) final-consonant weakening or deletion (pan 'bread' → ['pã], and tren 'train' → [ʳt̪ʲʷʲ(ʷ)eʰ]); and (3) consonant cluster reduction (tren 'train' → [t̪ʳæʰ], and troca 'truck' → [kʳoᵏgʳc]). In addition, J also preferred reduplicated syllables (C_1VC_1V); this will be shown below (section 3.3) by the uniform adjustment of non-paradigmatic words by the powerful consonant harmony conditions.

Of the twenty-one words (excluding the deictic words) produced by J on the first two sessions, eleven were adult (CV)CV words in which both consonants either were identical or agreed in manner. (An additional four were VCV and two were CVC words.) He attempted no three- or more-syllable words, and very few words containing consonant clusters.

3.3 Consonant co-occurrence

Powerful harmony conditions operated to minimize the complexity of the consonantal contrasts within J's words: if two consonants co-occurred in a word, they had to agree in place and manner. For example, gato 'cat' → ['ɖvt‿tˢɪ]; troca 'truck' → ['kˢok‿gˢa]; sopa 'soup' → [p̰ʰṵ | p̰ʰʷṵ]; mano 'hand' → [m̂a || m̂a]; pata 'paw' → [pˈɒ̰ˀ‿pʰa]; carro 'car' → ['kˢwa k‿kwuʰ]. Mono is an interesting exception: mono 'monkey' → ['ũn‿n̂ɔ̃] and [m̰ 'ũn‿no]. In the first production, the initial consonant was deleted, as was typical of the way in which the syllable structure of many words was simplified. In the second production, however, the first non-harmonized C_1:C_2 contrast was achieved: |m:n| a place contrast. Although |m| and |n| both appeared in the second mono, the production was not adult-like: the consonant and vowel of the first syllable were separated, with a brief pause following the initial syllabic |m| . This phenomenon, which will be referred to as 'temporal spacing', occurred frequently and is evidence of the difficulty J had in producing new sound combinations--in this case, a non-reduplicated C_1VC_2V word. Other examples of temporal spacing from the first two sessions are: ojo 'eye' → [ʔ̰o̰ʔ ɯ̰ ᵝβʷʌ]; ojo → ['ɤu | 'ɤhu]; sopa 'soup' → [p̰ʰṵ | p̰ʰʷṵ]; mano 'hand' → ['ma || m̂a]; mano → [m̰‿m̂ã̰]; and leche 'milk' → [tˢ‿'ʧɤʷʰ].

In addition to the harmony conditions, an initial consonant deletion process also operated to simplify the consonant structure of J's productions: mono 'monkey' → ['ũn‿n̂ɔ̃]; mira 'look' → [i jə]; and sopa 'soup' → [ʰᵊˀ‿pʰo].

J's limited consonantal inventory and the above harmony and simplification processes combined to produce the typical output of $(C_1)VC_1V$, in which the consonant was either a voiceless stop or a nasal. In general, the segmental (and syllable) structure of the adult words which J attempted were of the same, or very similar, shape and content--one or two syllable (C)VC(V) words where the consonants were either voiceless stops or nasals: mamá, papá, mono, mano, troca, pata; pan, tren; acá, aquí, qué. In addition, there were four CVCV words which did not agree completely in place or manner but also involved a voiceless stop (or a nasal) as one of the two consonants: gato, boca, sopa and carro (and possibly taza, although in this case the child's intended word was open to question); the deictic words mira and ésta/éste also may belong to this category, but in many respects constituted a special category (see the discussion above in 3.0). The only true exceptions to the above pattern were the adult fricative words leche, ojo (→ [o wo]) and agua (→ [aʊ wa]) (cf., also sopa and taza above), and the adult voiced stop-fricative word

guau guau (→ ['wa^{v} wɑ]). This close similarity between the structure of the adult words J used and his production abilities again (as in section 3.2) suggests a selection process in which J chose words to be added to his production lexicon, at least some times, on the basis of their phonetic complexity (cf., avoidance strategies in Ferguson/Farwell 1975).

3.4 Minor processes

Two minor processes appeared in J's earliest data: consonant prothesis and initial-consonant lenition; both of these functioned somewhat differently than the processes mentioned so far. In 3.2, the three syllable structure processes clearly worked to achieve the optimally simple syllable, CV. In 3.3, the consonant harmony conditions operated to simplify the consonant structure of words toward the C_1VC_1V goal. These general syllable structure and consonant co-occurrence constraints were compatible, in that both achieved simplification and neither resulted in a production which conflicted with the demands of the other. In contrast, both consonant prothesis and initial consonant lenition resulted in productions which were incompatible with the demands of one of the major types of constraints.

Consonant prothesis is a process by which an extra consonant (usually either [p] or [k]) was added to a vowel-initial word: ojo 'eye' → [ʔo^{v} hwɯ] ~ [k^{h}o^{v} ʷɯ ʰwʌ] ~ [wo wo]; and leche 'milk' → *eche → [l^{ʲ}ɪ]oʂ ʧɛh].[x] Although this process complicated the consonant structure of the words, it added to the uniformity of syllable structure in J's productions by producing CVCV word shapes. The other minor process, which was more common throughout the entire period of testing, was initial consonant lenition, a process by which an initial stop or nasal was weakened to a glide: mamá 'mother' → [wa^{ṽ}m̃ m̃a] and pata 'paw' → [^{h}ɯa^{v}t̃ t^{h}o]. This process is unusual in that it neither created CV syllables nor simplified the consonant structure of the words.

Given that J's favored syllable structure was the CV, the simplification process of initial consonant deletion (section 3.3) is also somewhat anomalous, in that it created VCV rather than CVCV word shapes, and occasionally deleted initial segments of an already harmonized adult word (e.g., mamá 'mother' → [^{h}um̃ m̃a] and papá 'father → [hʌp p^{h}ɯ^{wh}]. Synchronic dialect studies of adults show that unstressed syllable deletion is typical of both Mexican and Texas Spanish (the two dialect areas of J's parents) (see Lapesa 1965). In addition, a related process in Texas Spanish deletes initial consonants of an initial unstressed syllable: papá 'father' → apá, and mamá 'mother' → amá (Lance 1969, 47). It is not clear, however, that these dialect phenomena occur in the adult language as spoken to children, or how or why a child should abstract such a marginal pattern if the input is of the reduced form. Subsequent data (after the first two sessions) showed that the weakness of initial consonants and syllables--irrespective of stress--was a general characteristic of J.'s speech throughout the period of study (1;9 to 2;6). It seems probable that this early initial consonant deletion was part of J's

general tendency to lose the beginnings of words, and that the adult stress-related deletion processes mentioned above are merely similar to J's processes but not necessarily causally related.

It is likely that initial consonant lenition is also a part of J's tendency to lose the beginnings of words and, is thus related to initial consonant deletion, in spite of the fact that the first process complicated while the latter usually simplified the consonant structure of J's productions. Insofar as both processes--initial consonant deletion and initial consonant lenition--represent incomplete stages in the movement toward the CV syllable, both are best accounted for by the syllable structure (rather than by the consonant co-occurrence) constraints.

4.0 Developmental trends

In J's phonological system at the beginning of testing, strong syllable structure and consonant co-occurrence constraints simplified nearly all of J's productions to the form of CV or $(C_1)VC_1V$. In the period 1;9 to 2;6, these constraints were gradually modified, a development which resulted in a systematic increase in the complexity of J's words. The development in the complexity of syllable structure will be discussed in section 4.1 below, and that for consonant co-occurrence in section 4.2. In addition, the production form of any given word depended not only on the absolute characteristics of the syllable and consonant structure, but also on the dynamic interaction of changes in these two parameters during any given stage; this will be discussed in section 4.3, where it will be concluded that the limits on word complexity permitted at each stage are generally production performance constraints.[8]

Two types of data from J's corpus will be used: productions of adult words which contain a nasal consonant in final position (Table 3) and productions of adult words which contain a fricative consonant in initial or medial position (Table 4). The words which are included in these two tables are, for the most part, the first words acquired in each

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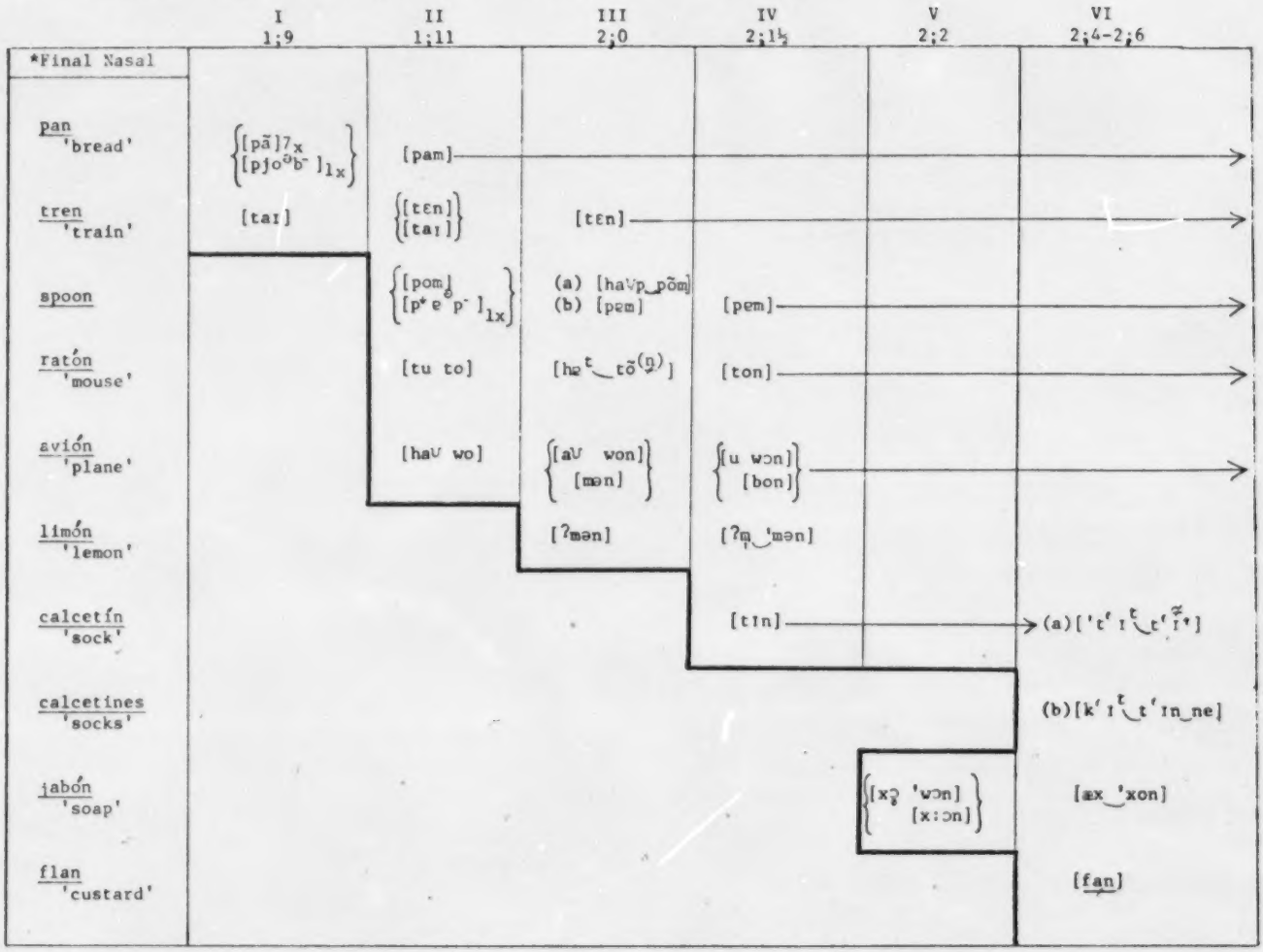
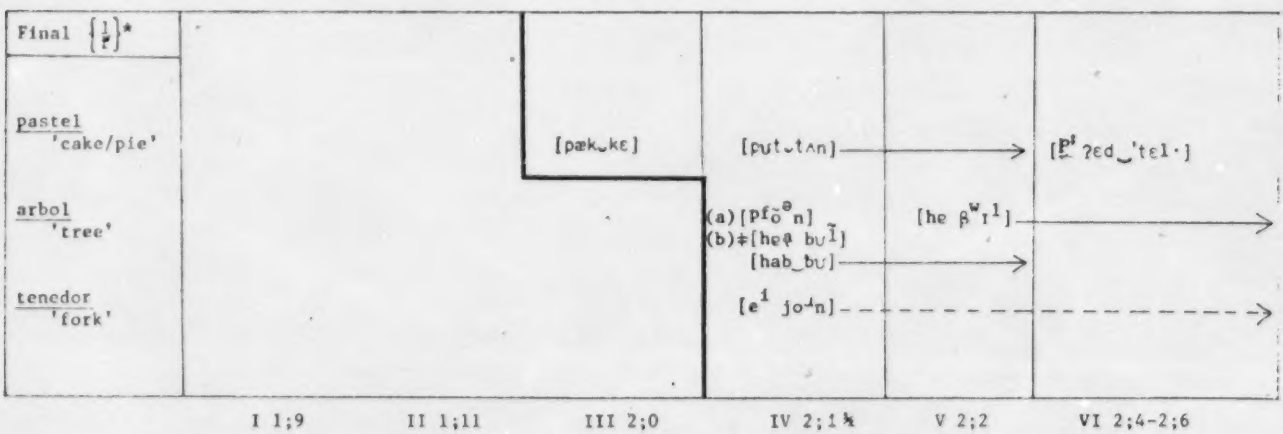
[8] The terminology 'production performance constraints (on words)' is used here to emphasize: (a) that production as opposed to perception was observed directly in this study; (b) that in these data the 'word' is at least one of the structural units of the lexicon (in addition to segments, syllables, etc.) and hence that phonological and phonetic conditions capture word shapes (similar to the way MSC's describe morphemes); and (c) that constraints on word complexity appear to operate (at least during some stages) at a surface, performance level. Of the several approaches to the currently very controversial issue of where to divide competence from performance (which includes controversy over the validity of the distinction itself), the use here of 'performance' (as rule-governed behavior) is closer to the view found in Fromkin 1968 (which deals directly with the 'syllable' as a unit of performance) than to that of Chomsky 1965.

Table 3. Stages in the acquisition of final nasals and final liquids



*The first seven words listed are the first seven nasal-final words used by J. The final two words are the first F+N words acquired.



*The three words listed are the first liquid-final words acquired by J.

{ } alternate forms

(a) (b) (a) precedes (b) in time

≠ progressive idiom; occurs only once

→ word remains in the same form (as last entered) throughout the time period indicated by arrow

-→ final [n] alternates with final Ø throughout the time period indicated by the broken arrow

Table 4. Stages in the acquisition of non-final fricatives*

	I 1;9½	II 1;10½	III 1;11½	IV 2;0	V 2;1	VI 2;1½	VII 2;3–2;6
A. leche 'milk'	{[t' 'tʃɪ^{Uh}] [ʔ$_{ɪ}$]o$_{ʒ}$ 'tʃɪh] [hjut‿tʊ]}		{[ʂ'tja ʃha] ['saus‿sɪ] [uɛ]‿[ʃe]}	→	→	[ɛ·^{I}ʃ]‿[ʃɪ] →	→
ojo 'eye'	[ʔo wo]	[x:‿xa] →					
sí 'yes'		[^{h}wi]	(a) [çi] →				
oso 'bear'		[[ʔ]od ^{t}ʃ]ə	(b) [^{h}au^{J}‿ʃo] →				
B. mesa 'table'			[me ^{p}fe]			[me^{Is}‿ʂje] →	
elefante 'elefant'		{[pað] [fje]}			[paɪ^{t}‿ti]	[fa^{d}n‿t'ɪ] →	
cuchara 'spoon'		[ɸ$_{ʒ}$a^{h}]			[kʊk‿k' ad$_{x}$də]	{[θja^{II}‿le] [ʃa^{t} je]}	(a) [t^{r}ə 't^{r}a {ʃ}ə] (b) {[t^{ɔ}ʌθ' 'θhaə̆‿ɛə] [t'^aɪ^{w}‿wa^{ʊ}' ʷge] [$_{L3}$'tθə̆ɪ^{t}‿ɹ'ɛ̂]}
C. casa 'house'			{[kɑ ‖ kɑ] [kak‿k^{h}e]} →	‡	{[k^{j}eɪ^{ɕ}‿ɕ^{j}e] [s̻ja^{s}‿st^{r}a]}	(a)[ja:ɪ^{s} ʃa] (b)[^{kx}has‿sa] (c)[k'a^{s}‿se] →	
taza 'cup'	[ʇ'ja]	{[ba^{p}‿phe] [tʃɑ tʃɑ]}	[ta^{t}‿ta] →	‡	{[t' e^{ʔh}‿hə^{ɕ}‿ɕe] [taʂ θə]}	['θa^{əs}‿se]	['ta^{əs}‿se]
D. sopa 'soup'	{[phu ‖ p^{w}u] [həp‿p'o]}	{[pop̻pa] [hap‿po]} →		‡	['put‿t^{h} ə]	{[fo^{p}‿ɸfa:] [fwop‿pa] [p^{w}op·‿p'a]}	(a)[k̂ɔp‿p^{ɔ}e] (b)[^{t}ʃ^{t}op‿p'^{ɔ}ah]

*The words contained in the table are the first ten voiceless fricative words acquired. The letters A–D refer to the order in which fricatives were acquired in different positions and environments.

{ } alternate forms

(a) (a) precedes (b) precedes (c) in time
(b)
(c)

‡ progressive idiom

→ word remains in the same form (as last entered) throughout the time period indicated by the arrow.

of the two categories, and are representative of the developmental patterns seen in all words of each type. The phonetic form given for each word at any stage is a transcription of an actual production of that word (i.e., not a composite/phonological representation) and was selected as being characteristic of all the productions for the particular word. If a transcription of a word does not appear in a column, the word was not produced during that time period. In both tables, stages are identified by roman numerals and represent some change in the surface production of final nasals or non-final fricatives. However, the time periods covered by the stages are different for each table. This is because each stage was determined individually for the different types of data. For example, Stage I for final nasals occurred at 1;9 and was characterized by nasal deletion; Stage II which began at 1;11 marked the addition of final nasals to one-syllable but not two-syllable words (Table 3). For the fricatives, Stage I began at 1;9½ with the correct production of [tʃ], and Stage II at 1;10½ with the correct production of fricatives in (V)CV words generally (Table 4).

4.1 Syllable structure

For both nasal-final words and fricative-words, i.e., words which have a final nasal or a non-final fricative in the adult model, J's productions showed a gradual increase in complexity in terms of the number, type and order of syllables. In these words, single syllable productions (both single syllable adult words and poly-syllabic adult words reduced to a single syllable in the child's production), and the simplest of two-syllable productions (i.e. VCV words) preceded two syllable productions of the form C_1VC_2V; all three types appeared well in advance of three-syllable productions. In terms of syllable type, CV was the most common, followed by CVC; no other syllable types were produced by J until the last few weeks of testing, when the first rudimentary CCV syllables were produced (e.g., trigo 'wheat' → ['kʰ [ɹ̥] ɟo] (2;5½)). With regard to order, concatenations of CV syllables (e.g., C_1VC_1V) were clearly the easiest--appearing both earlier in time and with much greater frequency. The only other definite order preference was for CV$CVC above CVC$CV.

Of the many common adult nasal-final words, J only attempted single syllable such words during Stage I, and in these, the final nasal was deleted (occasionally after having nasalized the preceding vowel). Final nasals were also added first to single syllable words, and in particular to those words which had a voiceless stop as the initial consonant: pan 'bread' → [pam] (similarly for pon 'put'); spoon → [pom]; and tren 'train' → [tɛn] (similarly for ten 'take') (Stage II, Table 3 above.) During this same stage, two-syllable, nasal-final words (which were attempted for the first time) underwent the nasal-deletion rule which operated on single syllable CVN words during Stage I: ratón 'mouse' → [tu to] and avión 'plane' → [hau wo] (Stage II). During Stage III, final nasals were added to two syllable words, and during Stage IV, the first three-

syllable nasal-final word (calcetín 'sock') was attempted but produced as a single syllable ([tin], Table 3). J had not produced a final nasal on a three-syllable production by the end of testing, when he was 2;6.

Among the nasal-final words, the primacy of the CV syllable was shown primarily through the operation of the final-consonant deletion rule, and secondarily through consonant cluster reduction: tren 'train' → [taɪ] (Stage I); and ratón 'mouse' → [tu to] (Stage II), Table 3. An exception was one production of limón 'lemon' during Stage IV: [ʔm‿ˈmɑn]. The syllable CVC first appeared in Stage II (pan 'bread' → [pam]). Although final liquids (/l/ and /r/) were treated by J as if they were final nasals, [CVN] syllables derived from an underlying /CVL/ did not appear until Stage IV; much later still (primarily during Stage VI), syllable types such as CVL appeared (e.g., pastel, árbol (Table 3); and from Stage VI hacer 'to make' → [ʰasˌsɛhˌ̥], the only production with a final r in the data).

In terms of the ordering of nasal final syllable types in a word, CV$CVN was easier than CVN$CV: ratón 'mouse' → [hɐ̯ᵗ‿tõ(n̯)], Stage III (2;0) Table 3; and (ele)fante 'elefant' → [paɪᵗ‿ti], Stage V (2;1) and then to [faᵈn tʻɪ] Stage VI (2;1½), Table 4. This difference suggests that, at least during Stages III to IV, the phonotactic constraints were more exactly word-structure rather than syllable-structure constraints.

For words containing at least one fricative, the development in syllable structure was similar. The voiceless fricatives were correctly produced first in intervocalic position of a VCV word and in initial position of a CV word: for example, ojo 'eye'→[xᵘ̯ xa] (Stage II); and sí 'yes' → [çi] and oso 'bear' → [ʰɐʊˢ‿so] (A., Stage III, Table 4). During these same stages, fricatives in C_1VC_2V words, where either the first consonant (C_1) or the second consonant (C_2) was a voiceless stop or a nasal, underwent (a) complete or (b) partial assimilation (for examples of (a) see casa, taza, and sopa, and for (b) see mesa, Table 4). Correct production of fricatives in the environment of a nasal or voiceless stop was achieved in two syllable CVCV words (B. and C., Stages VI through VII) before three syllable words (e.g. cuchara, Stage VI and VII) (Table 4). By the end of testing, J correctly produced fricatives in two-syllable words seventy-one percent of the time; however, in three-syllable words, the same fricatives were produced correctly only twenty-four percent of the time.

Among the fricative words, the primacy of the CV syllable was shown in several ways: (1) fricatives first appeared in CV (and VCV) productions (e.g., sí 'yes' → [çi], leche 'milk' → [ˈˈ‿ˈʧɤᵛʰ]; elefante 'elefant' → [ʃʲe]; cuchara 'spoon'→[dʒaʰ] Table 4); (2) two-syllable words were reduced to one syllable (e.g., taza 'cup' → [ʧʻjaˌ] Stage I); and (3) many fricative words went through one or both the stop-reduplication (e.g., taza → [taᵗ‿ta] Stage III), and the fricative reduplication

stages (e.g., taza → [ˢθaᵉˢ‿sɐ] Stage IV). Considerably more difficult for J were CVC syllables: of the two fricatives allowed in word-final position, /ð/ never was produced, and /s/ did not appear until Stage IV. Word-final |s| continued to have severe restrictions on its occurrence throughout the period of testing. From Stages IV to VI (2;0 to 2;2), final |s| appeared only in single syllable |sVs| words. In Stage VII (2;5½), it appeared in |VNVs| and |VFVs| words; finally, it was produced in |ŞVs| words, after a very brief period in which strongly released [t] consonants served as reflexes for the final |s| .

In terms of the ordering of fricative syllables in a word, CV$FV was somewhat easier than FV$CV (e.g., casa and taza (Stage VI) versus sopa (Stage VII) Table 4). Of the greatest difficulty were syllable sequences which placed fricatives contiguous with other consonants; in almost all such contexts, the fricative was deleted.

4.2 Consonant co-occurrence

The gradual development in the complexity of the consonant structure in any word depended crucially on the phonetic similarity of the consonants: the greater the similarity between two consonants, the fewer the restrictions on their co-occurrence in any word. The notion of phonetic similarity in phonological theory has always been difficult to specify: even when particular sounds have relatively constant phonetic properties, phonological systems of different languages vary in their organization of these phonetic data. Thus, similarity relationships among any particular set of sounds will be different in different languages and may be different even between individual language learners. In J's system, voiceless stops were more similar to nasals than to voiceless fricatives. For example, voiceless stops combined earlier with nasals than with voiceless fricatives in C_1VC_2V words:[9]

pan 'bread' → [pam] (1;11) tres 'three' → [tˀɾɛ$^{\theta}$] (2;6)

cama 'bed' → [mæ̃^{k}‿kə̃] (2;0) casa 'house' → [kaˢ‿sɐ] (2;1½)

Similarly, voiceless fricatives, which were more like nasals than like voiceless stops, combined first with nasals and then with stops:

mesa 'table' → [meˣʂ‿ʂɹɐ] (2;1½) taza 'cup' → [taᵉˢ‿sɐ] (2;3)

nariz 'nose' → [hanˑ‿nɹiˢ] (2;5½) patas 'paws' → [pɐt‿tˀɐˑˢθ] (2;6)

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[9] All words given in this section as showing the acquisition order among sets of consonant combinations were the first words produced correctly for any given type: for example, pan was the first single syllable Ş+N word and tres was the first single syllable Ş+F word.

Nasals, in occupying the middle position on the similarity scale combined more easily with voiceless stops and fricatives than either of the latter combined with each other. The question of whether nasals co-occurred with voiceless stops before co-occurring with voiceless fricatives (as would be expected) is somewhat problematic:

pan 'bread' → [pam] (1;11)	jabón 'soap → [x:ɔn] (2;2)
tren 'train' → [tɛn] (1;11)	flan, a custard → [fan] (2;5½)

Table 3

but

pluma 'pen' → [pʰhum_mɛ] (2;5½)	mesa 'table' → [meᶻˢ_sjɐ] (2;1½)
peine 'comb' → [pœd_ᵈnɛ] (2;2½)	Marcy, a nickname → ['mɐᶜ_ɕi] (2;1½)

Since members of a class are by definition more similar to each other than to members of another class (at least along the criterial dimension), consonants from all three classes of sounds first appeared in a CVC(V) word where the second consonant was also a member of the same class. This was reflected in the preponderance of complete and partial reduplications (with voiceless stops and nasals) in J's initial phonological system (see section 3.3) and the apparent reduplication stage which accompanied the learning of fricatives and possibly also liquids. The fricative reduplication stage occurred when a fricative was being realized on the surface in a new environment, for example:

leche 'milk' → [savs_sɪ],	Stage III
casa 'house' → [s̪ʲaˢ_stᶻa],	Stage V
taza 'cup' → [ˢθaᵊˢ_sɐ],	Stage IV
sopa 'soup' → [foᶠ_ɸfa:],	Stage VI

Table 4.

Correct production of liquids was just being learned by J at the end of the testing period, and a few liquid words showed evidence of a similar reduplication stage, for example:

cuchara 'spoon' →	[sˢəlᵈˢ_ɟˡlal_ɺlɛ],	8/29 (2;6) Table 4
rueda 'wheel' →	['pʰwe jɔ],	4/25 (2;1½),
→	['ʰɰʷɛˈɟ_ɟɛ],	8/22 (2;5½),
→	[l̃ɛ[ɾ̃]ᵗ_lᵗə],	8/22 (2;5½)
pelota 'ball' →	[ᵖfe],	2/7 (1;11),
→	[ᵖbɐaᵗ_to],	3/28 (2;0½),
→	[pʰʌl_luˣˡ/ɾ_l/ɣa],	4/18 (2;1½).

In addition to phonetic similarity as such, a strength hierarchy of consonant classes also determined the complexity of consonant co-occurrence in words. The operation of strength hierarchies has been posited for various languages and even universally.[10] In J's system, voiceless stops were stronger than nasals and voiceless fricatives, and nasals were stronger than voiceless fricatives. Using the formalization of a strength cover feature from Venneman and Ladefoged (1973), the hierarchy may be characterized as follows:

Voiceless stops [3 strength] ⟷ $[^{+stop}_{-nasal}]$

Nasals [2 strength] ⟷ $[^{-stop}_{+nasal}]$

Voiceless fricative [1 strength] ⟷ $[^{-stop}_{-nasal}]$.

This hierarchy is based on the functioning of these three classes of sounds in the consonant harmony rules; the position of other classes of Spanish consonants in J's hierarchy is not as clear. Probably as a result of the non-consonantal nature of glides /w/ and /j/, these sounds did not participate in the harmony rules and thus are not on the hierarchy. Except for a few isolated words, it was not until late in the course of the study that J began to use liquids, voiced stops and voiced fricatives; since the data on these consonants are not complete, they are not ranked in the consonant hierarchy. Furthermore, it appears that for most of this period of development they did not participate in the hierarchy at all. During the first five months of testing, J treated the voiced stops and voiced fricatives as one phonological class, whose members were usually realized as glides. The liquids also went through a stage in which they were produced as glides. For at least during their respective glide stages, these consonants--the voiced stops, voiced fricatives and liquids--gave no evidence of participation in the strength hierarchy.

The assignment of strength for each of the three 'true' consonant classes neatly captures the patterning of the assimilation rules--rules which operated at some level during the entire nine month period that J was tested.[11] J's initial phonology was characterized by complete and partial assimilation in which all two-consonant C_1VC_2V words were

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[10] For discussion of a strength hierarchy in diachronic change, see (for example) Foley 1970, and for evidence of a hierarchy in synchronic assimilation, see Hankamer/Aissen 1974. Since this paper was given, two papers have been published which discuss strength hierarchies in child phonology (see Menn 1975 and Kerek 1975).

[11] The functioning of the strength hierarchy in J's phonological development will be described in detail elsewhere. For the present, it can be summarized as accurately reflecting the general order in which segments were acquired, the progressive suppression of the constraints on the co-occurrence of consonants and most aspects of the acquisition of consonant clusters, in addition to the patterning of the assimilation rules. It does not reflect the nature of consonant- and syllable-deletion processes.

produced with all voiceless stops or nasals (section 3.3). Similarly powerful harmony conditions operated throughout the period of 1;9 to 2;6 and were gradually relaxed in ways captured by the strength hierarchy. Whereas in the early stages, all weaker consonants assimilated to the place and/or manner features of a stronger consonant in the word, in the later stages only those consonants where were distant on the hierarchy still participated in the harmony conditions. The direction of assimilation is as follows:

		Assimilation direction:
S̥	[3 strength]	--
N	[2 strength]	to voiceless stops, but not to voiceless fricatives
F̥	[1 strength]	to nasals and to voiceless stops.

In Table 3, the strength relationship between voiceless stops and nasals is shown by the (highly productive) assimilation rule which adjusted the nasal place of articulation to agree with that of the voiceless stop: pan 'bread' → [pam], Stage II.

The alternation of [ʌʊ won] with [mən] for Stage II avión 'plane' (Table 3) gives evidence for the non-participation of glides in the hierarchy, in that the surface realization of [w] did not affect assimilation or syllable simplification. The form [mən] however signals a change of w to b in the processing of the word for production.[12] The complexity of the new segmental contrast caused simplification in two ways: (1) loss of the first syllable (which had been consistently produced since the word's first appearance); and (2) further minimization of the segmental difference by the operation of manner harmony (i.e., b → m). The ways in which segmental and syllable complexity interact (demonstrated in (1) above) will be discussed further in section 4.3. The process stated in (2) is the earliest example that suggests that, at the time when voiced stops and fricatives came to be realized as non-glides on the surface, they underwent assimilation in a manner consistent with a position on the hierarchy below the nasals and the voiceless stops.

Not shown on Table 3, the development of peine 'comb' demonstrated very clearly the strength relationship between voiceless stops and nasals and the gradual development in complexity from complete to partial assimilation to complete accuracy:

2/14	['b/peɪp_pèe]	1;11
2/28	['pɐet̚_t̚ˢɹ̥ʰ]	2;0
5/23	['pèeɪ ˌjo]	2;2½
	[pɑɐd̚_d̚nɛ]	
	[peɪn_nʌ]	

[12] In adult Spanish, the orthographic v of avión is pronounced as [β].

Data from Table 4 demonstrate all the strength relationships. That voiceless stops were stronger than nasals can be seen in: (1) elefante 'elefant' → [paɓ], where first /f/→[p] and then /n/ assimilated to [p]; and (2) elefante → [paɾ^{t}‿ti], where /n$t/ → [t].[13] Only one example of the assimilatory power that nasals had over voiceless fricatives is given in Table 4: mesa 'table' → [me ᵖfe], Stage III. Other examples are:

teléfono 'telephone' → [mɛn‿nʊ̃] 4/18 (2;1½); → {[fən‿no] / [ˈθ̪ɔ̃ˑ‿so]} 8/1 (2;5)

chango 'monkey' → {[ˈx̟ˑʒ‿ɲ x̟ɔ̃ˑ] / [ˈx̟ˑʒ‿ɲ ʒ̟ˑ]} 8/22 (2;5½)

Examples of the strength of nasals over voiceless fricatives were fewer (than examples of voiceless stops over fricatives) because fewer CVCV words containing a nasal and a voiceless fricative occurred in the corpus. Those words which did appear all behaved in the above manner.

The significant degree to which voiceless stops [3 strength] were stronger than voiceless fricatives [1 strength] was shown in three ways: (1) the early complete assimilation of fricatives to stops; (2) the relatively late productions of S+F words; and (3) the evidence which demonstrates the amount of difficulty J had in combining such consonants. For all S+F words acquired in the first three months (1;9-2;0), the fricative assimilated to the stop when and if a reflex was produced at all: casa 'house' → [kɑk‿kʰɐ], Stage III (see also taza and sopa) Table 4. Fricatives were realized as stops in such words at the same time that they were produced correctly in #(V)CV# words (see ojo, sí, oso Table 4). Likewise, when fricatives were correctly produced in two syllable S+F words, they typically assimilated to the stop in three syllable S+F(+X) words (e.g., cuchara 'spoon' → [t̃ʰʊ̃ɐ̃ˑ‿ʤˑʊ̃ˑ ʤˑɹ̃] Stage VII, in contrast to casa, Table 4).

As mentioned above, S+F words were correctly produced (at about 2;2) later than words of other forms: S+S at 1;9 (e.g., pato 'duck'); N+N at 1;9 (mano 'hand'); N+S at 1;11 (peine 'comb'); and N+F at 2;1½ (mesa 'table'). Even at the point at which the S+F words were typically

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[13] This example is typical of a highly regular consonant cluster reduction rule in which nasals were uniformly deleted before voiceless stops; in nasal+voiced stop clusters, the stop was deleted. Moreover, NS clusters were learned before NS̬ clusters. These facts again would suggest the positioning of voiced stops below nasals on the strength hierarchy. However, the functioning of consonant clusters with respect to the strength hierarchy relationships was complicated and will be dealt with in detail elsewhere.

produced with a stop and a fricative, they were phonetically less stable for a longer period of time than words containing other consonant combinations. The phenomenon of temporal spacing (an additional indicator of difficulty) was often characteristic of the first productions in which both the voiceless stop and fricative appeared: taza 'cup' → [tʰɛ²h_haə_ɕɛ] and casa 'house' → [kʰa² has_sa], (Table 4).

Probably the most interesting evidence of the difficulty that S+F combinations presented was the brief 'progressive idiom' stage that several of these words went through. For example, taza 'cup' was regularly produced as [tata] from 1;9 to 2;0. During Stage V (at 2;1), it was produced as [tasa], although the phonetic variation of the six productions showed that J was having difficulty with the word. However, the phonetic accuracy of this stage was lost during Stage VI (2;1½) when taza was regularized to [sasa]. At this point J used his old rule of reduplication, as a means of stabilizing a new and difficult sound, /s/. During Stage VII (2;3 to 2;6), taza again became [tasa]; and at this stage, it was produced correctly with much greater phonetic consistency (cf. a related discussion in Moskowitz 1973 and 1975 on the differences between phonetic versus phonological acquisition). On the basis of J's productions of [tata] and [tasa] (Stages III and V, respectively), it can be reasonably assumed that J's perception and storage of taza included |t| as the initial consonant. However, the initial |t| was produced as [s] during Stage VI. Rather than infer a loss of a contrast, it seems reasonable to assume that the change in initial segments was due to a performance constraint which limited surface phonetic complexity in order to minimize the difficulty of producing this word at this stage. It is at this stage (VI) that we have the strongest evidence that the harmony conditions were surface production constraints which operated within the performance unit of the word. To claim that the harmony seen at Stage III (when taza was produced as [tata]) was also due to surface performance constraints would be to assume that J perceived the adult /s/ correctly but produced it as [t]; in these data, there is no evidence for such an assumption (cf., Smith 1973 for stronger claims concerning 'underlying representations').

4.3 Interaction of syllable structure and consonant co-occurrence

In the preceding section, the alternate forms of [aʊ won] and [mən] for avión 'plane' were discussed. The premise of that analysis was that, for at least some words, there was an interaction between the complexity of the syllable structure and the complexity of the co-occurring consonants. The process of such an interaction will be discussed here. Also in that section, the change in the surface forms for taza (from [tata] to [sasa]) was discussed; it was suggested that the fricative reduplication stage was an attempt to 'stabilize' the newly produced |s| (cf. Moskowitz 1973 on reduplication) and that reduplication was a means of minimizing the demands placed on the performance abilities. It will be suggested here that the change in surface form which results from the direct interaction of syllable structure and consonant co-occurrence (avión) and from the

surface acquisition of new and difficult sounds (taza) is the most convincing evidence that the complexity constraints that have been described above are reflections of limits on production performance.

Table 5 gives the chronological development of four words: taza and cuchara (which are also contained in Table 4); and silla and tenedor. These four words were chosen as the best examples of the interaction between the two parameters of complexity being discussed, primarily because they are words which were produced frequently throughout the course of testing and, hence, are words for which there are several productions at each stage of development.

Table 5. Four words showing the interaction of syllable structure and consonant co-occurrence

		taza 'cup'				silla 'chair'	
(1)	12/18 ≠	'tʲja	(1;9½)	(1)	4/ 4	ʃːˢa	(2;1)
(2)	2/21	ta^{t}_ta	(1;11)	(2)	4/25	hi ja	
(3)	3/28	t^{r}ɐ^{zh}_ho^{ç}_çɐ	(2;0)	(3)	5/ 2	{kʳi jɐ / tʲiː jaʰ}	(2;2)
(4)	4/18	'sja^{s}_sjɐ	(2;1)	(4)	5/23	{ʃi ja / çi ja}	(2;2½)
(5)	5/23	'ta^{əs}_sɐ	(2;2)				

		cuchara 'spoon'				tenedor 'fork'	
(1)	1/31 ≠	ʤ^{ʒ}a^{h}	(1;10)	(1)	4/25 ≠	e 'jɒ^{ɹ}n	(2;1)
(2)	4/ 4 ≠	kʊk_kʲaʤ_ʤa	(2;1)	(2)	5/23	'nʌ jə	(2;3)
(3)	5/30	{'ʃa^{ɪ} jɐ / θja^{ɪ}l_lɐ}	(2;3)	(3)	8/ 1	{hɛ^{ʧ}_l^{ɹ}ɔ^{ɹ} / ʔʌe^{ɪ}ʤ^{ɹ}_ʤ^{ɹ}əʌ}	(2;5)
(4)	8/ 1	t^{r}hɐ^{ʤ}_'ʤ^{ɹ}ɐ ʤ^{ɹ}ɐ	(2;5)	(4)	8/15 ≠	ˌkʰdɪ 'ə ɔ n	(2;5½)
	8/ 8	t^{ʰ}ʌθ^{ɹ}_'θhəð_ðə					
	8/15	'tθ̞ə̃l^{ʲ}_l^{ɹ}ɐ̃					
(5)	8/29 ≠	s^{ɹ}ɐl^{ʒ}_'ʒ^{ɹ}ləl^{ʤ}_lɐ	(2;6)	(5)	8/29	tʃ^{ɹ}ɐ^{ʒ}_ʒ^{ɹ}ə^{ʒ}_ʒ^{ɹ}ə	(2;6)

≠ production of a type which appears only once in the corpus.

In taza, the change in surface accuracy resulted from the interaction of the segments being produced; the syllable structure of CVCV remained accurate. The other three examples show a similar loss of surface segmental accuracy; in these words, however, the loss resulted from the interaction of syllable structure and segmental contrasts. In silla 'chair' and cuchara 'spoon', the correct production of the initial |s| and |tʃ| (both of which were word initial in J's early production) was lost when the word acquired a two and three syllable form, respectively. This process was repeated in cuchara, when the accurate surface form of ʂVLV (time period 3) reverted to ʂVʂVSV during the change from two syllable to three syllable structure. In tenedor 'fork', the final consonant was lost when the word changed from a simpler canonical shape V$GVC (time period 1) to a more complex one CV$GV (time period 2) and again when it changed from two syllables (4) to three syllables (5).

In these words (and in many others), the simultaneous realization of complex syllable and consonant structures exceeded J's production abilities. Depending on the particular stage of development, the conflict between the demands of syllable and consonant structure was resolved by increasing the accuracy of one parameter at the expense of accuracy in the other. This 'trade-off' reflected the particular limits at each stage on the permitted complexity of spoken words.

Thus, for J the 'word' was a unit of production performance which, because of his developmental immaturity, had specifiable complexity limits. Although the difference between competence and performance is not identical in an adult (who has learned a grammar) and a child (who is learning one), an analogy may be drawn between J's performance limits on word complexity and adult performance limits on sentence length and complexity (for example, the limits on the number of grammatically well-formed embedded clauses which may occur in a spoken sentence).

To summarize, J's development from 1;9 to 2;6 was characterized by the gradual increase in the number, type and order of syllables in words and by the gradual relaxation of restrictions on the phonetic similarity and strength features of co-occurring consonants in words. In addition, the development of many words clearly demonstrated that J's ability to coordinate in production the syllable and consonant structures of complex words also improved systematically. At all stages, differences in the production of phonemes and syllables were related to the influences of the phonetic context of a word and also to position in the word. The developmental progression seen in these phonological data was one in which each stage could be stated in terms of specific limitations on permitted complexity. It is similar to the development noted by Bellugi 1968 for the acquisition of negation and to that described in Waterson 1975 for the acquisition of phonology and syntax, and may reflect a general psychological process at work in many aspects of language acquisition.

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Appendix Diacritics, symbols and transcription conventions used in text examples, excluding those of the I.P.A. inventory*

DIACRITICS

Releases	[˚]	unaspirated	[ᶠ]	amorphous frication	[ᶠ̬]	wet fricated
	[ʰ]	aspirated	[̬]	wet	[ʸ]	voiced
	[ˆ]	snap				
Place	[ₘ]	heavily dentalized	[ₜ̪]	protruded tongue tip	[ₗ₂]	laminal contact
Manner	[ˡ]	lateralized	[ˇ]	trilled	[ⓥ]	incipient trill
	[ₒ]	spread	[ₕ]	aspirated	[₌]	flat
	[ₐ]	wet	[—]	fricated	[‿]	breathy
	[‗]	strong	[˷]	weak	[⁻⁻⁻]	laryngealization
	[⁻⁻⁻]	intermittency				
Timing	[˘]	clipped				
Vowel Quality	[¯]	high pitched	[₋]	whispered		

SEGMENTS

[ɸ]	a stopped [f]	[ɬ]	voiceless fricative lateral
[β]	voiced fricative [b]	[ɖ]	alveolar slit fricative

CONVENTIONS

[C C]	a space between symbols indicates a syllable or word boundary
[C‿C]	a ligature across a syllable boundary means the intervocalic consonant is allied to both syllables
[C|C]	a vertical line between symbols indicates an unusual pause
$[^{C_C}{\sim}^{C_V}]$	superscript position indicates weakness
$\begin{bmatrix} C_1 \\ [C_2] \end{bmatrix}$	a symbol in a subscripted position indicates a secondary percept
$\left[\begin{bmatrix} C_1 \\ C_2 \end{bmatrix}\right]$	symbols in brackets mean a composite sound having the qualities of both symbols
$[C_1/C_2]$	symbols separated by a slant line are alternative transcriptions
[(C)]	a symbol in parentheses is questionable (may not have occurred)

*For complete discussion of the transcription system used by the Project, see Bush et al. 1973.